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The objectives of this study were to 1) explore the feasibility and benefits of incorporating interactive job-aiding techniques into an interface to electronic documentation for depot-level maintenance tasks, 2) identify candidate job tasks for electronic aiding, 3) develop an initial concept for an interactive maintenance-aiding system (IMAS), and 4) develop a roadmap for implementation of an IMAS, including prototype development.

The relationship of the proposed interface-oriented IMAS to the paper-oriented Automated Technical Order System (ATOS) is discussed. It is recommended that a menu-based authoring system for creating state-of-the-art electronic aiding interfaces, using ATOS and related files as input, be developed. This authoring system would allow depot maintenance managers and supervisors to compose, compile, and update maintenance-aiding materials to be used for interactive presentation to the technician.

Prototype development and implementation plans are presented for two application areas: the Precision Measurement and Equipment Lab (PMEL) and F-16 checkout.

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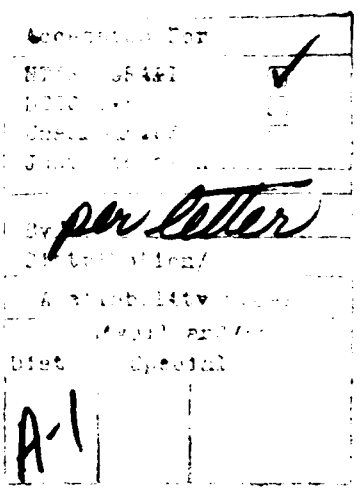

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

This executive summary provides a brief overview of the objectives, approach, findings, and recommendations of a study of the needs of depot-level maintenance technicians for interactive information aids in job performance. The study was performed under contract to Battelle by Honeywell's Systems and Research Center (Contract No. DAAG29-81-D-0100).

The main report of this study provides a more thorough discussion of each point summarized here. As an aid to the reader, cross-references are provided to sections in the main report.

OBJECTIVES

The objectives of this study are listed below.

- Explore the feasibility and benefits of incorporating interactive maintenance-aiding techniques into an electronic documentation interface for depot maintenance.
- Identify candidate job tasks for electronic aiding.
- Develop an initial concept for an interactive maintenance-aiding system (IMAS).
- Develop a roadmap for implementation of a depot-level IMAS, including development of prototypes.

APPROACH

The approach consisted of five basic steps.

- Collect information on a variety of maintenance tasks at Ogden Air Logistics Center (ALC).
- Identify candidates for IMAS applications in job areas offering potential benefit.
- Recommend a limited subset of candidate applications for near-term system development.
- Describe IMAS prototypes for development.
- Create a development roadmap for installation of an IMAS at Ogden ALC.

FINDINGS

According to an Ogden aircraft maintenance supervisor, up to 50% of a technician's time during F-16 checkout and trouble-shooting following modifications is spent in paper-based information search. Other sources report that 30% of total job time is consumed by this activity. (For more information, see subsections 2.3 and 2.4.1 in the main report, also entitled "Analysis of Applications for an Interactive Maintenance-Aiding System.")

Even with improvements in documentation (e.g., the MIDAS system), cross-indexing among F-16 modifications (more than 800), multiple aircraft models, and various applicable maintenance and checkout procedures is overly time-consuming, complex, and error-prone. It is the cause of significant cognitive workload for the technician. (See subsection 2.4.1 in the main report.)

In cockpit checkout procedures, technicians often work in teams of two, with one technician dedicated solely to calling out Technical Order (TO) procedures. (See subsection 2.4.1.)

Technicians would welcome a system that selects the necessary TO procedures to perform a given task. Aiding and task simplification are also desirable.

A significant number of tasks in the Precision Measurement Equipment Laboratory (PMEL) satisfy many of the criteria for application of job-aiding techniques and would significantly benefit from an electronic aiding system. (See subsection 2.4.2.)

Many tasks at PMEL tend to be lengthy and/or infrequently performed and involve a wide variety of equipment (over 2000 devices), equipment versions, and underlying principles and technologies. This diversity and infrequency of performance creates substantial problems in long-term memory and perception for PMEL technicians. Continuous interactive use of TOs is necessary. (See subsection 2.4.2.)

PMEL TOs are much less complete than TOs designed for less experienced technicians (e.g., MIDAS). PMEL TOs tend to be high-level, expert-to-expert communications, inadequate to direct the performance of a nonexpert without on-site expert guidance or training. (See subsection 2.4.2.)

Because PMEL TOs lack the procedural detail for nonexpert use, PMEL relies on a small number of subject matter experts who have learned the procedures not available in the TOs and who are the only individuals qualified to perform certain tasks. Their unavailability can cause delays in maintenance activities. (See subsection 2.4.2.)

Significant time at PMEL is spent writing and rewriting TOs or supplementing commercially provided calibration and maintenance TOs. (See subsection 2.4.2.1.)

Tasks in the Landing Gear Division, Sheet Metal Shop, and Automatic Test Equipment Facility will not benefit enough from electronic aiding to merit further investigation. These tasks are well structured and performed frequently so that they are mastered and generally memorized even when lengthy and complex. Real-time interactive use of TOs is not routinely required. (See subsections 2.4.3, 2.4.4, and 2.4.5.)

In its present form, the Automated Technical Order System (ATOS) is not capable of providing the maintenance interface needed by depot-level technicians. Though ATOS may achieve substantial savings in preparation, printing, and distribution of hard copy, it is paper based and not well suited to the sophisticated aiding and information presentation techniques achievable through the application of existing advanced electronic documentation interface technologies. (See subsections 1.3.2, 1.3.3, and 1.4.)

RECOMMENDATIONS

Our recommendations, based on this study of IMAS applications, are listed below.

- Provide the Ogden ALC with a technician-oriented IMAS for directly aiding technicians in job performance through advanced information access, integration, and presentation techniques (see Figure 1). (See subsections 3.1 and 3.2 in main report.)

- Adopt the three-year implementation roadmap for developing an IMAS at the Ogden ALC, as shown in Figure 2. The roadmap consists of a four-phase prototype development plan embedded in a long-range implementation plan. Prototype development will allow:

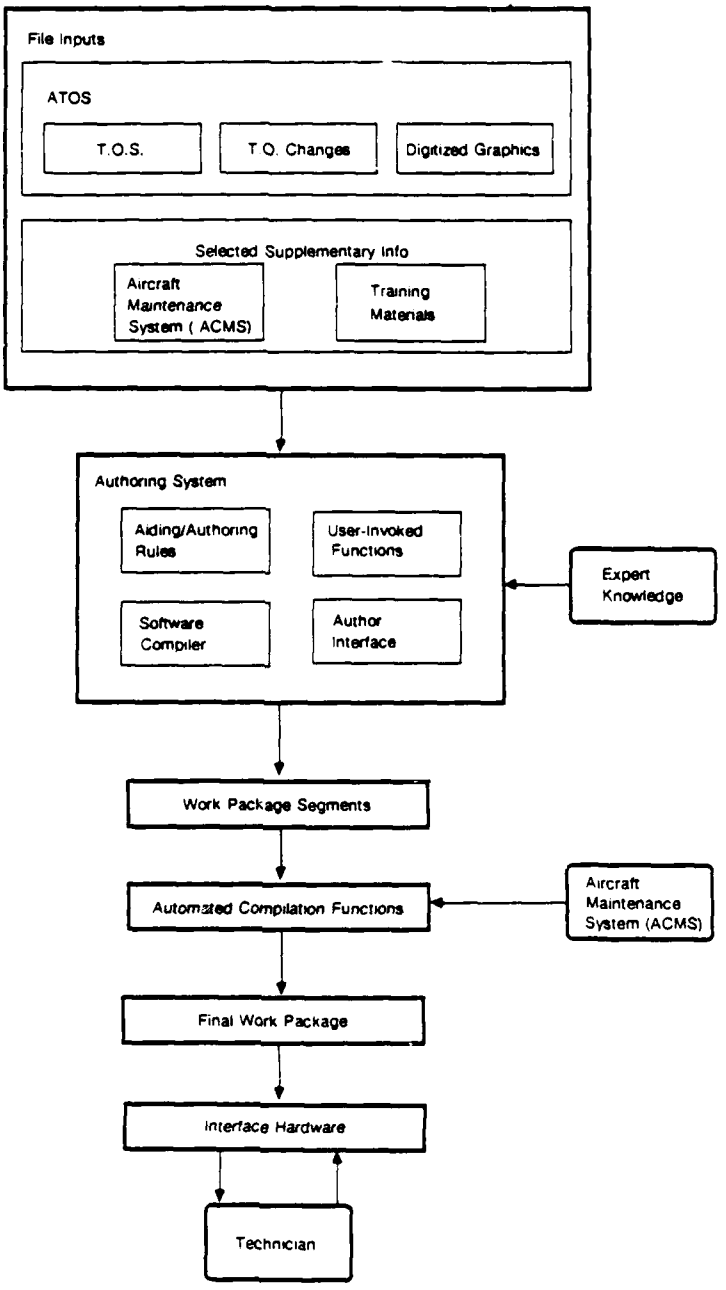

Figure 1. Architecture of the Major Components of IMAS

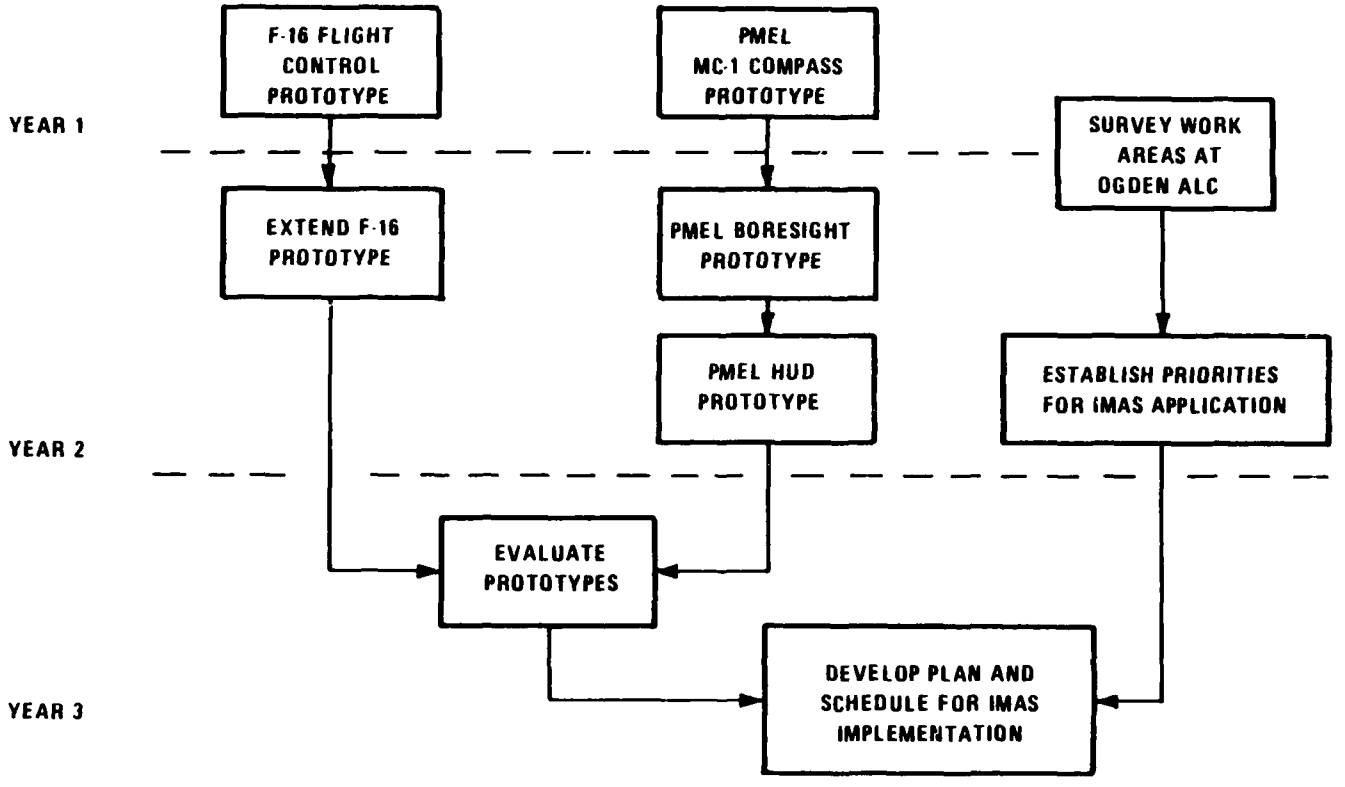

Figure 2. Roadmap for Implementing an Interactive Maintenance-Aiding System at Ogden ALC

--Real-time testing of advanced electronic information delivery techniques
--Evaluation of system utility
--Identification of pragmatic implementation problems
--Estimation of cost/benefit factors
--Validation of system concepts

The long-range implementation plan extends the prototypes into other depot maintenance activities. The plan is compatible with related Air Force programs: ATOS, Integrated Maintenance Information System (IMIS), and Flight Control Maintenance Diagnostics System (FCMDS). (See subsections 4.1 and 4.2.)

- Build two initial IMAS prototypes: an F-16 application for checkout of the flight control system and a PMEL application for calibration of optical equipment. (See subsection 4.3.)

- Provide the Ogden depot with the means for locally preparing electronic job performance-aiding interfaces. These interface "work packages" will be run by the technician on hardware appropriate to the task area (e.g., hand-held devices or benchtop terminals). They will create an interface that integrates procedures, information, and pictures into instructions for performing specific tasks. The interface will reflect advanced state-of-the-art aiding and presentation techniques. (See subsections 3.1 and 4.3.)

- Develop an authoring system for creating the necessary work packages. This system will be capable of taking ATOS and other supplementary files as input, guiding an author through a simple series of steps to transform the input into an integrated aiding package, and ultimately generating a set of work packages (programs and data) to be run on delivery hardware. (See subsections 3.1.1, 3.1.2, and 4.3.)

- Perform concurrent, parallel development of the prototype applications and the authoring system. As aiding techniques prove beneficial, they will be incorporated as authoring system capabilities. (See subsection 4.2.)

- Ensure that work packages are portable software that can be eventually incorporated into a lightweight, portable, hand-held device such as the Grid Compass being developed under the Air Force Human Resources Laboratory's (AFHRL's) IMIS program. (See subsections 3.1.2 and 4.2.)

- Examine ATOS for compatibility with an IMAS authoring concept and ensure that additional ATOS file characteristics (e.g., embedded control characters) are incorporated where needed. This would enable the most complete automation of the proposed authoring system, including standardization of work package characteristics. (See subsections 3.1.1 and 3.1.3.)

- Perform collateral studies to:
  --Identify and design the necessary authoring system help functions and decision aids for the author
  --Determine the aiding techniques required by specific maintenance task characteristics
  --Determine the desirability of incorporating embedded training functions as part of the interface's explanation capabilities
  (See subsection 4.4.)

- Initiate the requirements analysis for prototype development. The level of effort should be one person-year executed in a six-month period. The objective of the contract should be to provide the information necessary for a statement of work to be used in a procurement to build the prototype aiding demonstrations in F-16 flight control and PMEL applications. (See subsection 4.5.)

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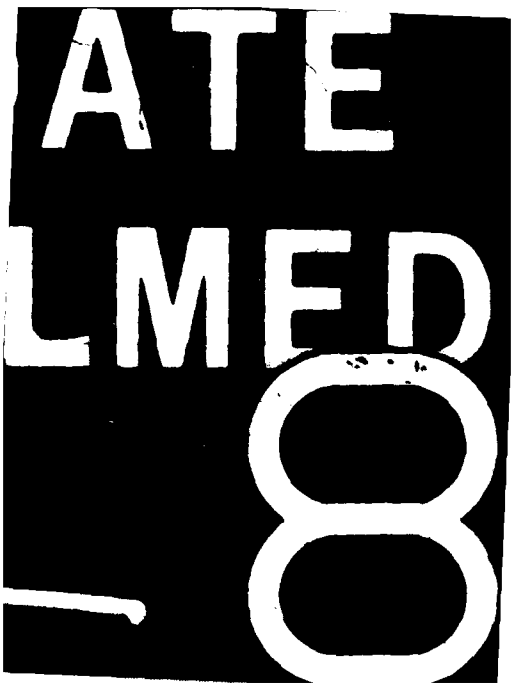
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